The VLTI now and in the future

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Outline

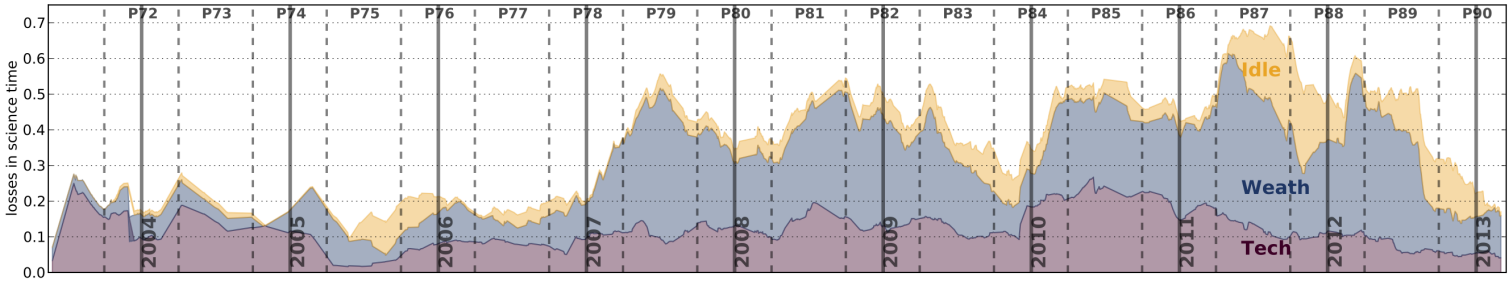
VLTI status

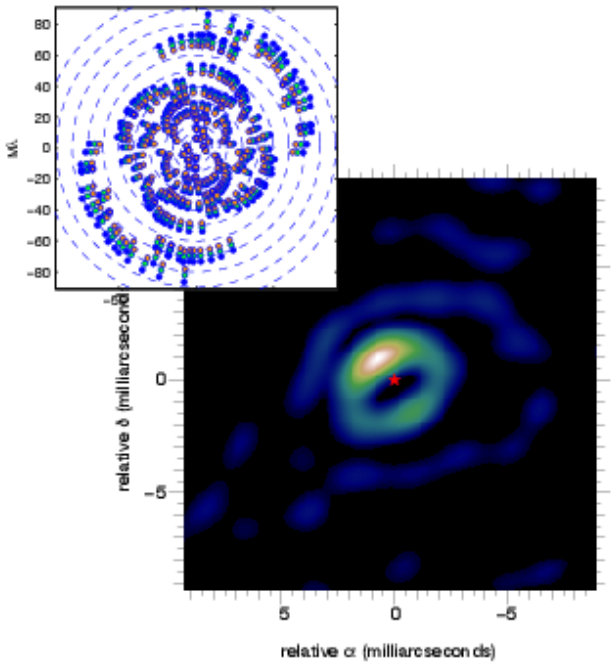
VLTI in a nutshell

- Array of 4 ATs (1.8m) or 4 UT (8m);
- Four telescope configurations offered;
- Two official instruments: AMBER (H,K) , MIDI (N);
- Visitor instrument: PIONIER (H);
- Visitor, Service, Delegated visitor modes;
- P90: Science time 80%;

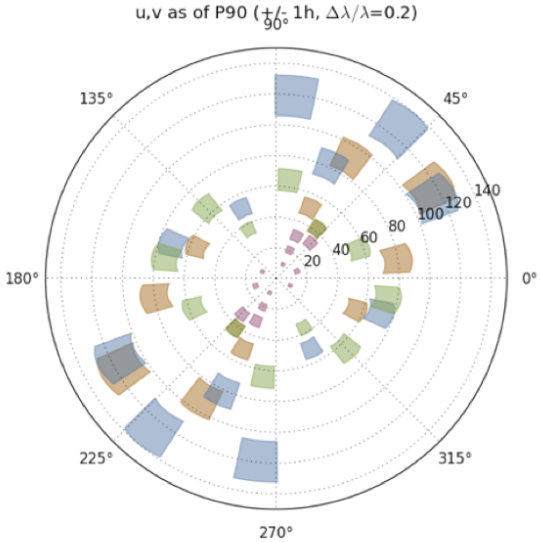
VLTI: successes

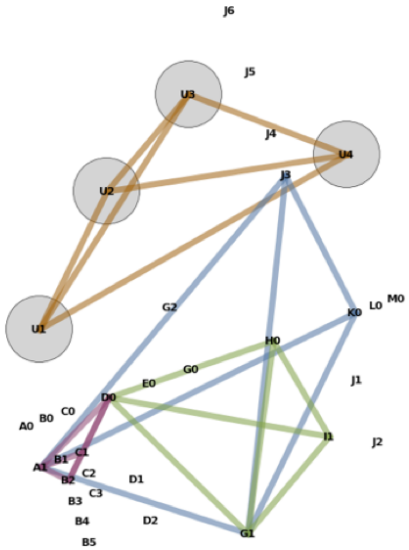
Downtime



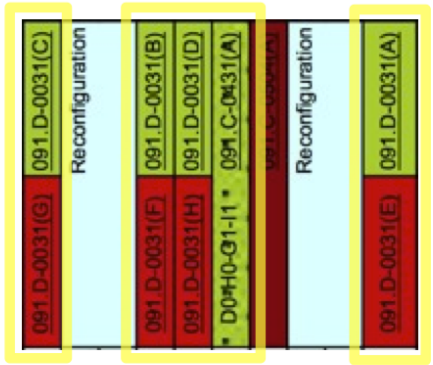


AT configurations



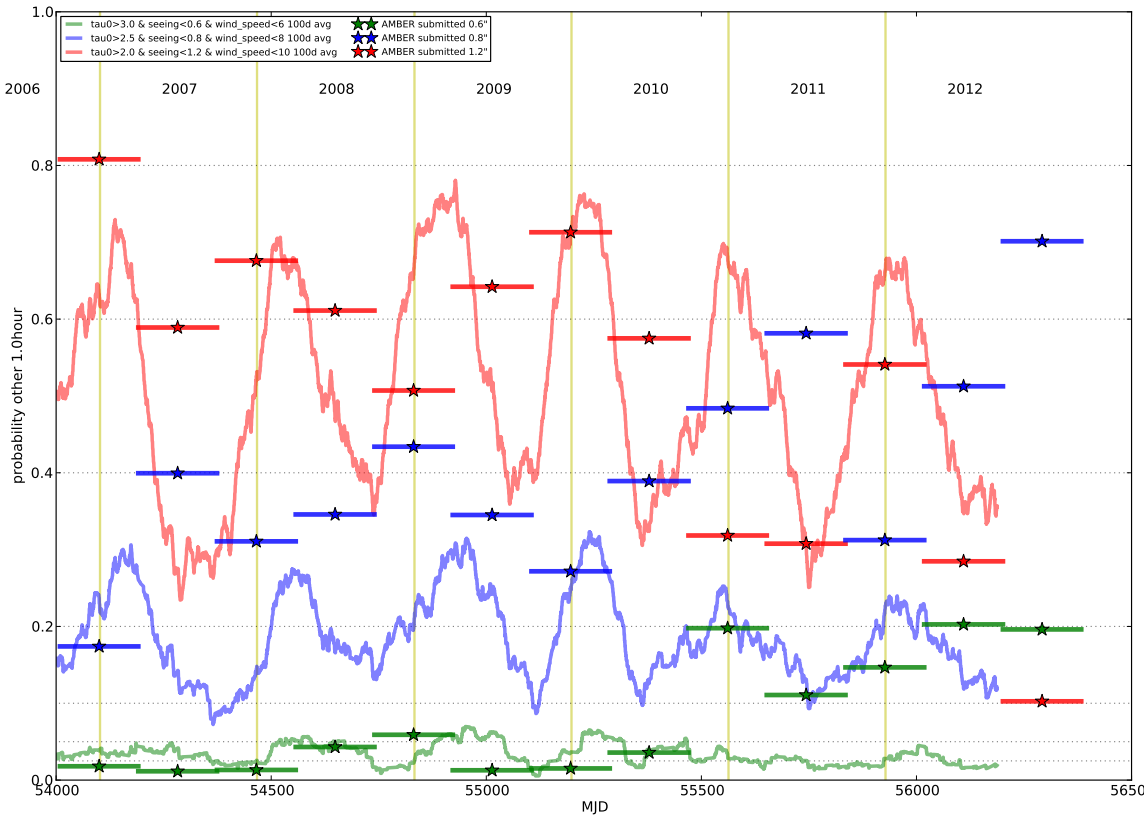


- relocation: 15 to 34 nights/period;
- 2 ATs per day;
- 1/2 test night after relocation;
- intermediate configs not used;
- user request based schedule;



April 2013: **4n** relocation for **5n** VM program

Lessons learnt (1): Seeing conditions at Paranal



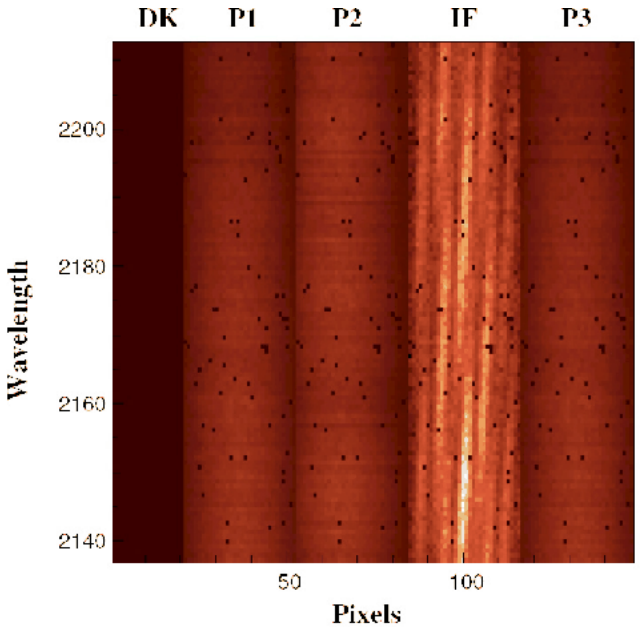
- Paranal can be a harsh interferometric site;
- Correcting atmosphere effects is not an option.

Lessons learnt (2): Fringe tracking

- FINITO: H band 3T fringe tracker (AMBER); i
- PRIMA-FSU: K band 2T fringe tracker (MIDI);

After ≈ 8 years:

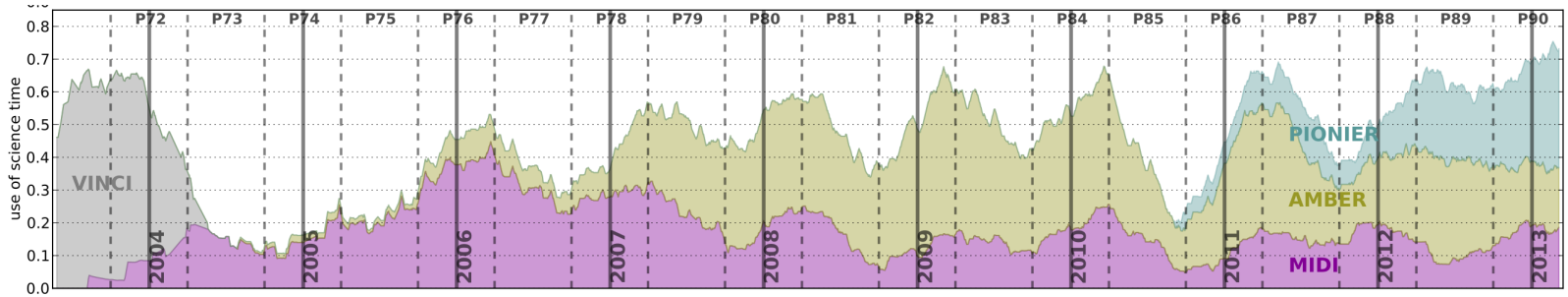
- Vibrations:
  - Killer on UT Array;
  - *no instrument* experiment ≈ 250 nm rms (120 nm needed for GRAVITY)
  - FINITO, FSU and limiting magnitude and true phase locking ratio suffered;
  - AMBER low transfer function;
  - originate partly in telescope structure
- Flux injection (ATs): hampering Finito/FSU performances;



Lessons learnt (3): Operation

- Maintaining a 24/24, 365/365 service, visitor mode: operating interferometer:
  - is great;
  - is very challenging;
  - it has a cost (manpower, technical, flexibility, reputation).
- Astrometry is ***very*** hard if it is the only thing you are doing.
- Astrometry is ***extremely*** hard if it is not the only thing you are doing.

VLTI usage: instruments



- AMBER had a slow start, Medium resolution K a hit;
- PIONIER (visitor instrument) currently 40% of scheduled time
- MIDI proposals + 25% since P90 because PRIMA-FSU (AT sensitivity $\approx \times 10$)

MIDI

- 2 telescope, N band combiner;
- Proposals raised by 30% with new PRIMA-FSU + MIDI mode;
- Critical wavelength window that will disappear until MATISSE;
- Extended in P93 (GRAVITY delay)
- Fate: To be removed at the start of lab work.

AMBER

- 3 telescope, (J) H and K, R 35, 1500, 12000
- Good data reduction support (JMMC);
- Suffered from FINITO degraded performances;
- Strong competition from PIONIER in low resolution;
- Medium/High spectral resolution is AMBER's strength;
- Existence of an AMBER++ alternative to amdlib (fainter,F. Millour);
- frontal competition when GRAVITY arrives
- High spectral resolution very interesting but limited by lack of FT;
- Fate: Will remain on the mountain until GRAVITY is fully operational.

PIONIER

- Visitor instrument, 4 telescope, H band R $\approx$ 5,40;
- Accounts for $\approx$ 40% of scheduled time;
- New potential ”game-changing” camera end of 2013;
- LSP(STC) recommended to study its extension on the mountain;
- Discussion with PI-institute on the conditions of transfer to ESO;
- Demonstrator for future phase 3 products delivery (calibrated data);
- offered in visitor mode for P93;
- Fate: Leaves when Gravity arrives. Will be prolongated if proper technical solution can be found;

PRIMA

Goals:

- 2T fringe tracking for MIDI and AMBER (faint science);
- 2 telescope astrometry in K band ($\approx 20 - 50\mu$as).

So, what's going on with PRIMA ?

a Commissioning process interrupted;

b Major system issues identified;

c Switched to "engineering mode" to enable experimental astrometry;

d Principle of a *G*ate Review examined by management;

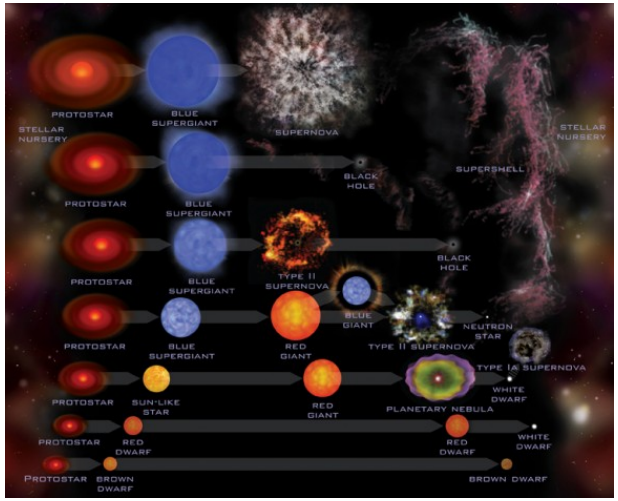
  i Assesment of the current/expected PRIMA performances;
  ii Establishing a recovery plan and the costs/delays associated;
  iii Confronting the exoplanet science with and updated view of the field.

e Establish a go/no go pathway based on technical, scientific, operational and managerial assessment.

VLTI scientific use

VLTI: hunting terrain

- **Stars from birth to death**;
- **Binary stars: from birth to death**;
- **Active galactic nuclei**;
- **Galactic center, Clusters**;
- Minor bodies;
- Exoplanet (direct detection, astrometry);
- AGN BLR;
- Lensing;

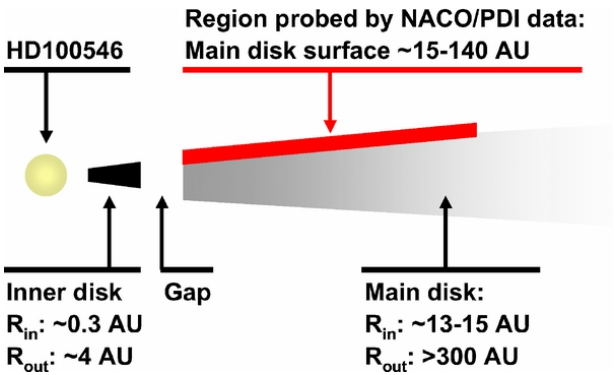


Strengths (/competition): uv coverage, fringe tracking, multiwavelength

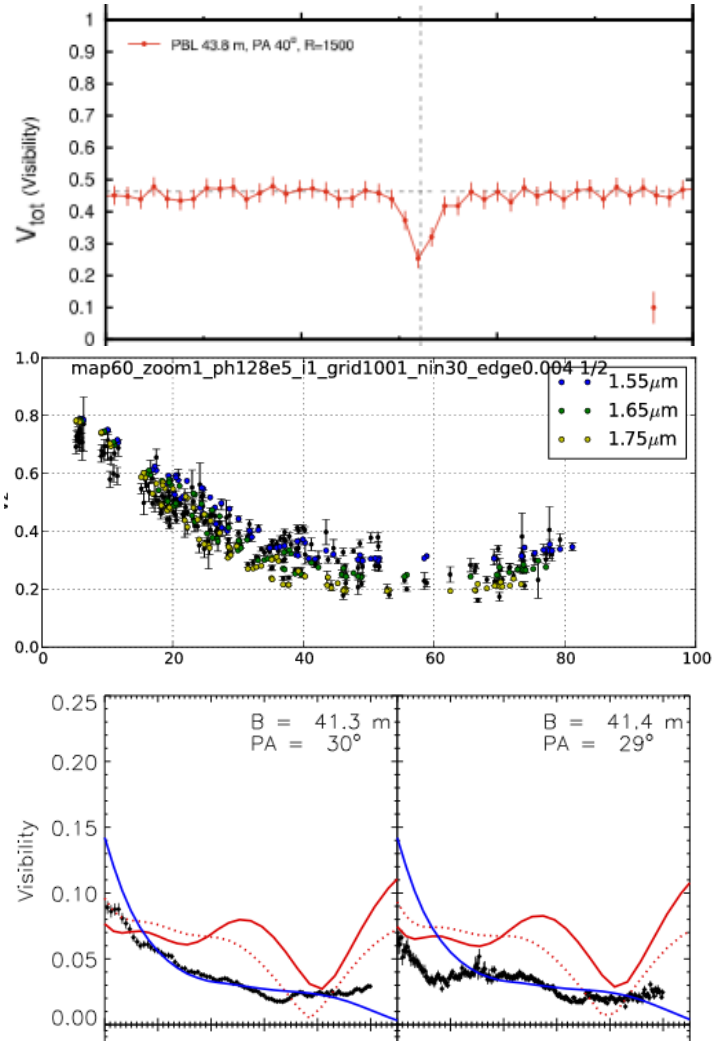
Weakness (/competition): angular resolution.

→ Spectrally and spatially resolved circumstellar environments, AGN torus (fundamental stellar parameters, pulsation not so present);

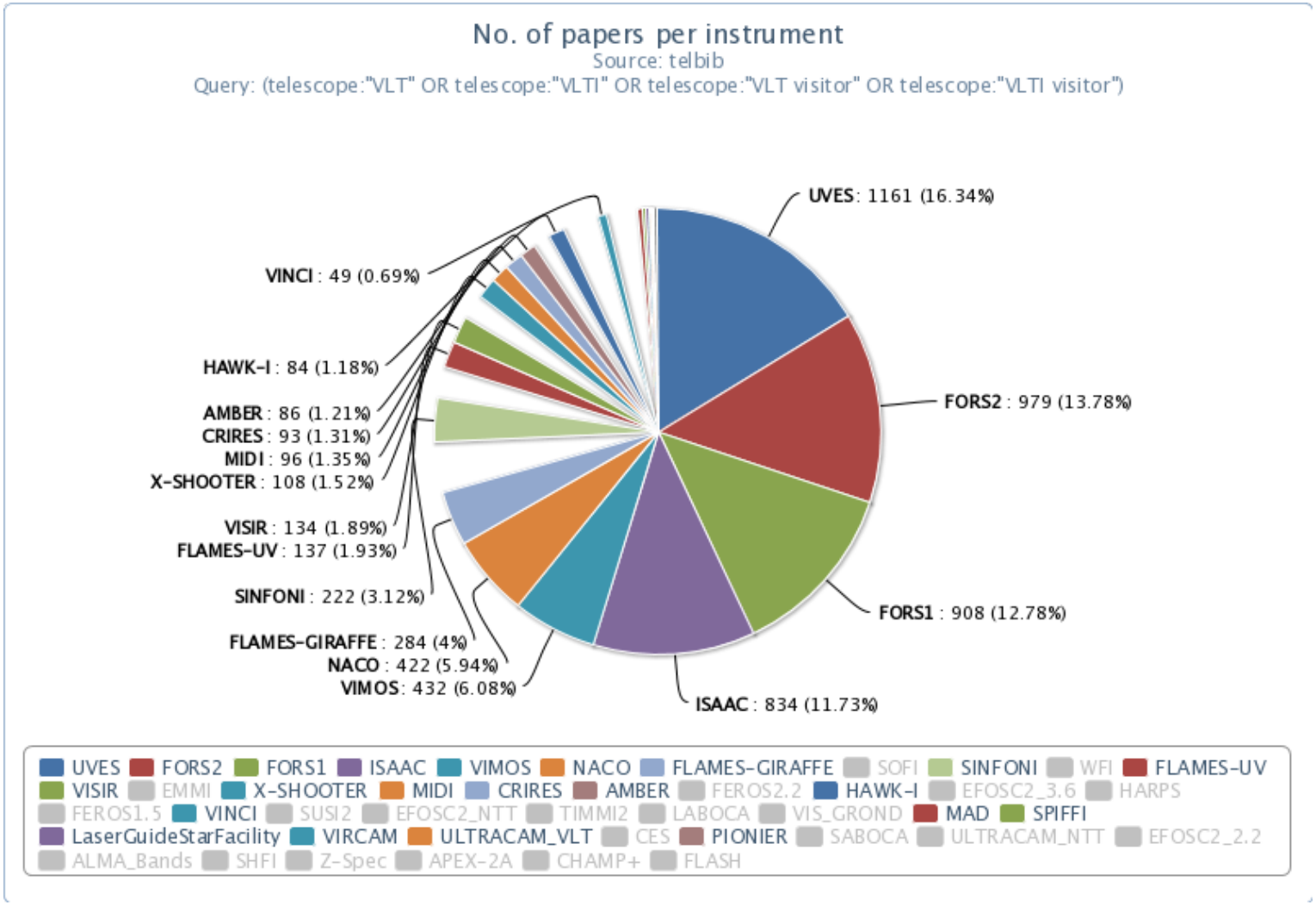
VLTI: multiwavelength, multitechnique



- Multiwavelength use of VLTI not widespread;
- Multitechnique use of VLTI is not widespread (e.g ALMA)

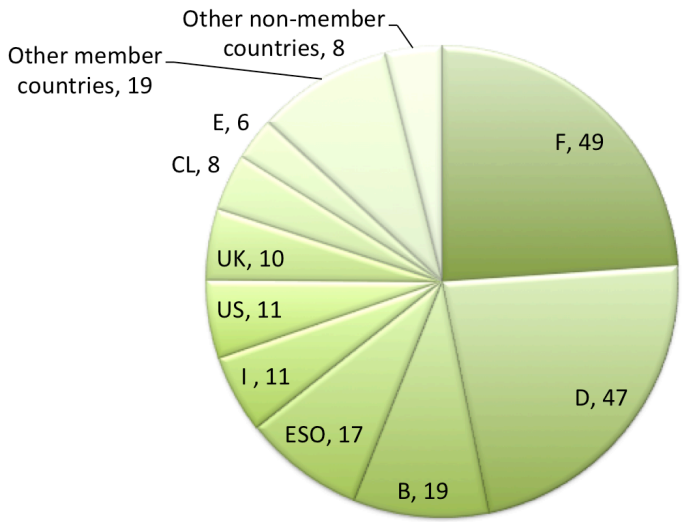


VLTI productivity

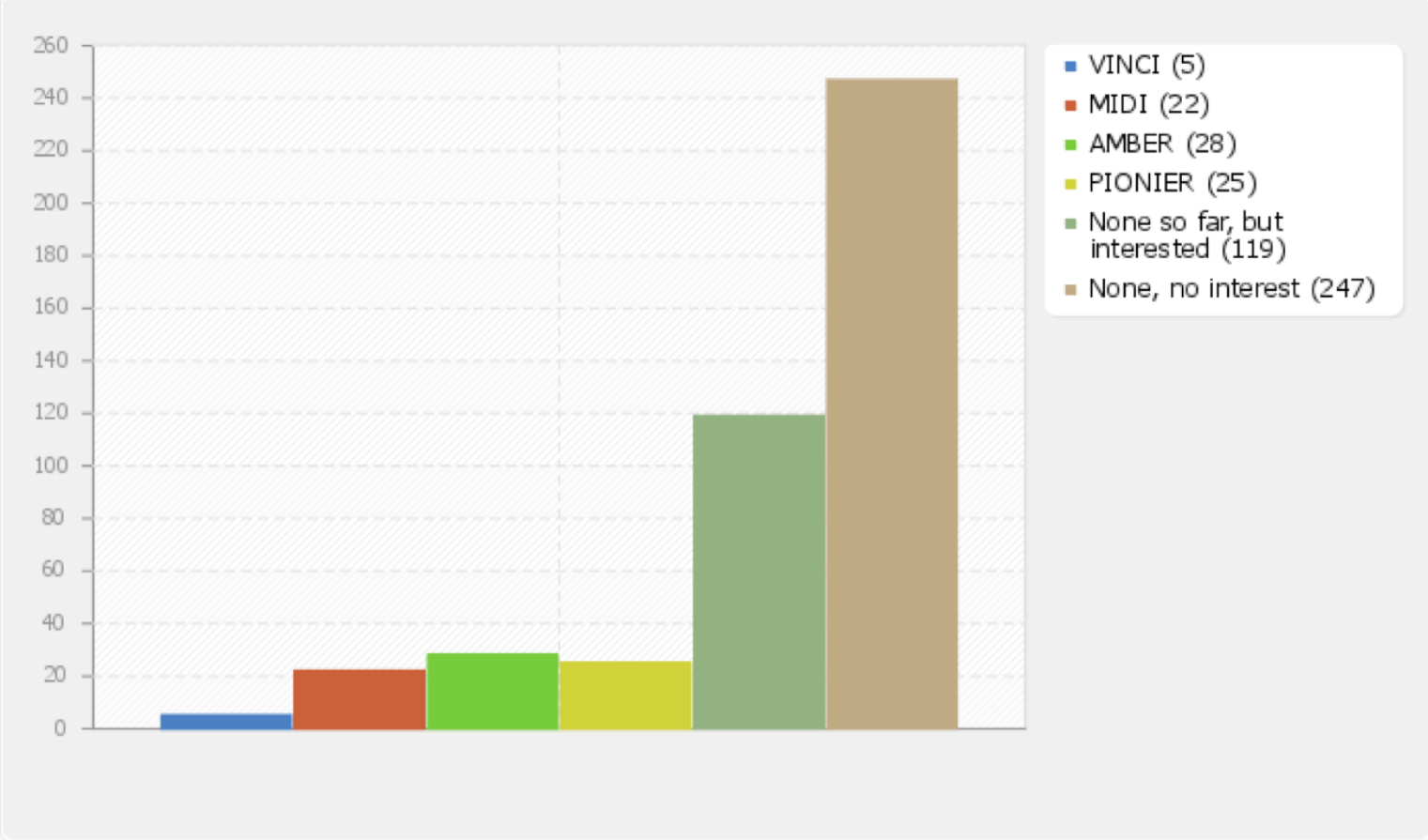


VLTI Users

- 205 PIs (up to P90);
- 137 PIs with more than 1 program (recurrent users);
- from 22 countries;
- many 1st time users
- many more astronomers indicated an interest (UC poll)



User's committee: VLTI poll



1.2% 5.1% 6.5% 5.8% 27.5% 57.0%

The good/the “to be improved”

Good

- Pressure factor on VLTI is very healthy (5);
- Excellent community support for VLTI exploitation (JMMC-Aspro, JMMC-SearchCal, JMMC-Litpro, data reduction);
- Excellent community support for schools;
- OLBI still has un untaped potential of users;
- Untaped potential science cases very important.

To be improved

- little use of Large programs;
- little use of filler programs;
- little use of VLTI multiwavelength capability;
- little access to non interferometrist community

Preparing for the next generation instruments

Gravity and Matisse in a nutshell

GRAVITY

- K band 4T “imaging” and “astrometric” machine;
- Spectral resolution 22, 500, 4000
- internal fringes tracker ($K \approx 7$ ATs, $K \approx 11$ UTs);
- UT sensitivity if off axis reference target within FOV (2”): $K \approx 15$
- astrometry 10 μ as in 5 mn on

MATISSE

- L, M, N band 4T imaging;
- L&M Spectral resolution ($\approx$) 30, 500, 950
- N Spectral resolution ($\approx$) 30, 220
- requires external fringe tracker;
- Sensitivity: L (ATs) $\approx$ 0.1 Jy (UTs) $\approx$0.01 Jy
- Sensitivity: N (ATs) $\approx$ 1.5 Jy (UTs) $\approx$0.1 Jy

Subsystems links and priorities

UTs

P0 Control vibrations, MACAOs

- Enable fringe tracking
- Enable Gravity's GC program
- Enable Gravity's SMBH mass measurement program

⇓

P1 External Fringe tracking capability

- Increase Matisse sensitivity by x10/20
- Enable Matisse spectroscopy
- Enable Matisse Core Extragalactic program (AGN sample few $\rightarrow$ 20);
- Enable Matisse Core Disk dynamics program

ATs

P0 NAOMI

- Increase ''dramatically'' the robustness of VLTI ATs to bad seing conditions;
- Stabilize injection in fringe tracker.
- Enable Gravity spectroscopy.

⇓

P1 External fringe tracking capability

- Increase Matisse sensitivity by x10/20
- Transfer programs from UTs to ATs;
- Enable Matisse spectroscopy;
- Enable 90% of YSO Core program;

Instrumentation and facility upgrade agenda

- Gravity: PAE fall 2014, shipment Oct 2014, Installation: March 2015
- Matisse: Gravity + 1 year
- ATs dual feed preparation (UTs, ATs) completed mid-2016;
- NAOMI (ATs adaptive optics): Call for Tender on corrective optics, delay in PDR (early 2014 ?)
- 2GFT (2nd generation fringe tracker): Technical specifications done but very likely delayed
- PIONIER and MIDI: out starting period 94 (october 2014);
- PIONIER back in period 95 (?) ... if technical solution.

Aperture synthesis: new operation model ?

How to operate the VLTI in the “imaging” - “astrometric” era ?

- What telescopes configurations will be offered ?
- What flexibility can we offer ?
- 4T out of 6;
- Adapt preparation/observing tools to imaging and astrometric programs;
- Implement the delivery of final reduced and calibrated products;
- Dedicated workshops to prepare users to the exploitation of PIONIER, GRAVITY and MATISSE;
- Ease the access to the VLTI.

Medium and Longer term view on VLTI

ESO: Medium and Longer term

Projects not funded and strongly linked to the ELT decision. To be included in the global ‘’VLT in the ELT era” context.

Two timescales:

- medium (until 2020): likely hampered by current project delays
- longer (2020 . . .), the “ELT era”

ESO: Medium and Longer term

WARNING: from now on pure speculation
needs GRAVITY and MATISSE successful
needs very strong science case

Possible projects:

a 3rd generation instrument at VLTI very competitive (financially speaking), don't necessarily need 10 Meuros to open new scientific avenues;

b Unexplored bands: J (very interesting lines) angular resolution improved by $\times$ 2 with respect to K band.

c Unexplored bands: Visible: strong interest to enable fundamental stellar parameters estimation at VLTI.

d Extension of VLTI to 6 telescopes ? :first 2UTs/4ATs then array extension

e Open a visitor focus to test new ideas (6T nullers, visible combiners, direct imagers);

Concluding remarks

Good points

- Huge progress in understanding VLTI from a system point of view;
- Less technical dowtime;
- Time dedicated to science has increased ($\approx$ UTs);
- VLTI integrated in VLT operations (same proposal, OB preparation tools);
- Pressure factor “healthy”;
- uv plane coverage capability much improved;
- User has total control of uv/time coverage (LST & configs);
- Vast amount of VLTI scientific potential untapped.

Not so good/Areas of improvement

- Sky coverage;
- Infrastructure not yet to the level requested;
- “Survey” potential of VLTI not used;
- VLTI not sufficiently used in the “multitechnique” context;
- Too many proposals requesting good seeing conditions (AMBER 80% s$\leq$ 0.8”);
- Low number of Service Mode Nights, low requests, visitor instruments;
- rationalisation of the scheduling.

Final words

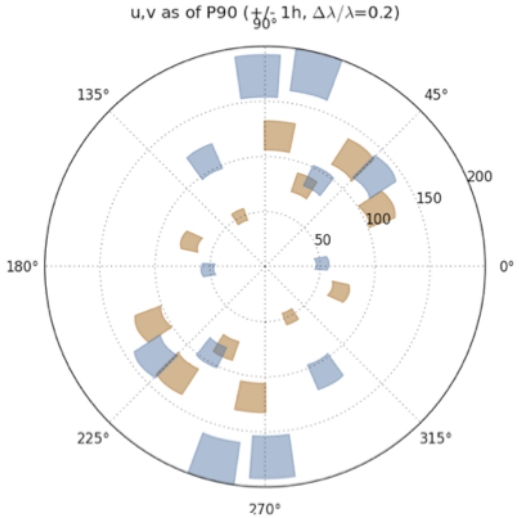
- We are not stagnating, these are exciting times;
- We need to make VLTI a success;
- ESO's responsibility
  - internally: don't pretend VLTI can do what it can't;
  - prepare the infrastructure;
  - provide a good user experience;
  - provide a good data-flow experience.
- Community's responsibility
  - be realistic about your expectations;
  - provide user support;
  - be aggressive in advertising VLTI;
  - be creative/generous in facilitating the access to VLTI;
  - decide what you want to do with the VLTI.

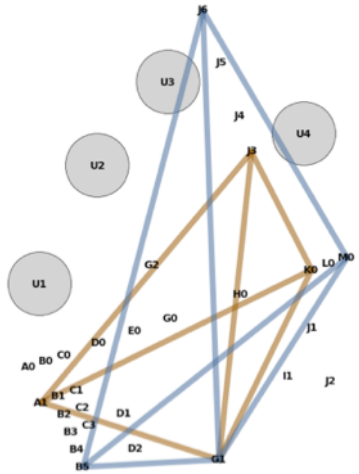
PIONIER science meeting
&
VLTI Community day (ESO/EII/IPAG)

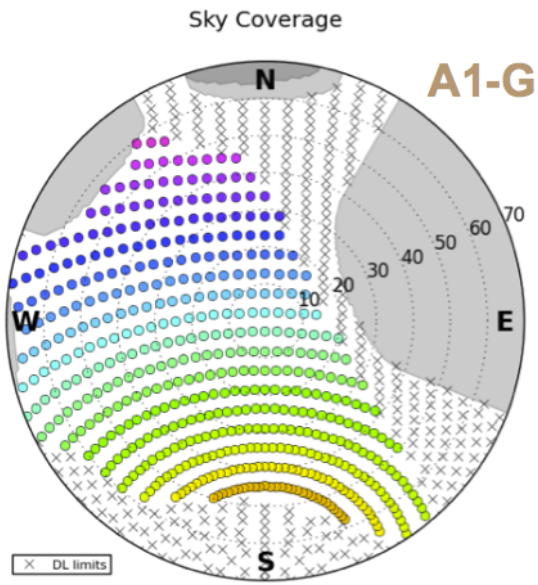
Likely: January 13-15th 2014 (Grenoble, France)

Additional slides

Sky coverage







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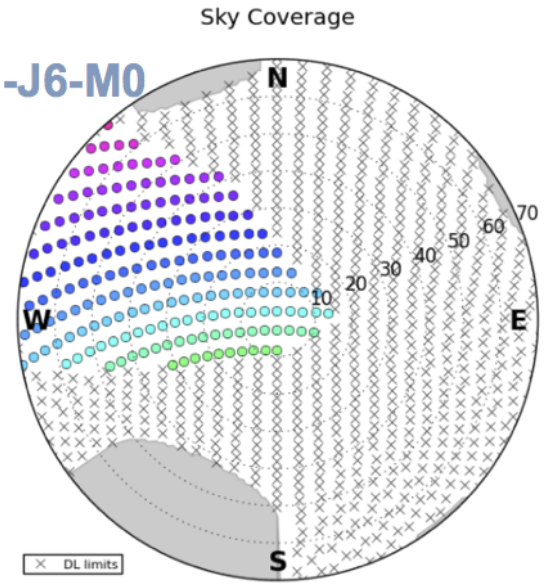

Sensitivity

	H (ATs)	K (ATs)	K (UTs)
AMBER	6.0	6.0	8.5
PIONIER	7.5 (9.0)		
GRAVITY		>8	>10

Table 2 : Comparison of MIDI (offered) and MATISSE expected performances.

	MIDI		MIDI + FSU		MATISSE +2GFT	
ATs	20Jy (@12 mic)	N = 0.9	1Jy(@12mic)	N =4.1	1.6Jy(@12mic)	N=3.4
UTs	1Jy (@12 mic)	N = 4.2	50mJy(@12mic)	N = 7.4	0.125Jy(@12mic)	N=6.2